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Fig.1

This report, drawn up by CNES in collaboration with the French space science community provides highlights on space sciences in France since the last edition of COSPAR report in 2016. It includes both an overview of current research programmes in Earth System, Space Science and Social Science and also a selection of remarkable scientific results obtained over this period. The activities follow the CNES Scientific Prospective Seminar, held in La Rochelle in 2014, the mid-term situation that was drawn up in 2017, and the preparation of the next seminar scheduled for 2019.

First of all, remember that among the missions assigned to CNES by the French government, the French space agency organises national research in the space sciences. It has no research laboratories of its own but works jointly with the French scientific community, especially through public research laboratories and organisations, which it provides with technical and financial support.

There are two sides to the French space programme: i) participation in programmes run by the European Space Agency, with CNES managing the French contribution to ESA, and ii) programmes carried out outside this framework, almost all of which are undertaken through bilateral or multilateral partnerships.

The last 2 years have been rich in programmatic decisions and noteworthy scientific results: CNES has been strongly involved in the space component of the Conferences Of Parties (COP) especially through the French-German MERLIN project and the on-going development of the MICROCARB mission. The deployment of the Spatial Climate Observatory will complete and catalyse all efforts in this area. The 2016-2017 period was also marked by the historic announcement of gravitational-wave detection by ground observatories which now offers the prospect of a new space observation window on the Universe. In the wake of

GAIA which released its second star catalogue in April 2018, we are entering the era of high-volume data-driven scientific missions based on digital mass processing.

**EARTH SYSTEM**

In Earth Science, the space component of the Copernicus European programme has been implemented since the launch of the first SENTINEL missions. CNES is involved at different levels in this operational programme and provides data to national actors via the PEPS platform. JASON-3 is currently the altimetry reference mission of Copernicus. To organise this oceanographic altimetry mission in the long term, which is crucial in the context of monitoring global warming, the JASON-CS-A/SENTINEL-6A and JASON-CS-B/SENTINEL-6B satellites will be equipped with instruments comparable to JASON in order to ensure the continuity of measurements.

CNES supports the exploitation of a dozen missions, and in some cases the corresponding operations, most of which are part of an international collaboration. Moreover, the implementation of 4 data and services centres for space-based and in-situ data distribution and utilisation is almost complete. These data centres are set up by CNES in collaboration with other national research organisations. They operate as a network linked to the European structure.

With CNES' impulse and as an extension of the One Planet Summit held in Paris in December 2017, space agencies linked with international organisations, are preparing for the birth of the Space Climate Observatory which will unite the efforts of international agencies and institutions on this theme in order to provide studies and services solutions at both global and regional scale.

August 2017 saw the launch of the VENUS mission developed in collaboration with Israel. In the meantime, it demonstrated the strong potential of the fine temporal scale analysis for the

monitoring of vegetation through its first results. The SWIM instrument on CFOSAT has been delivered to China and is now in the final integration phase. SWOT with NASA is in development. The IASI-NG programme with EUMETSAT will involve 3 identical instruments on the future METOP-SG platforms with both operational and research goals. As for ESA's Earth Explorer programme, the BIOMASS mission - proposed by the French community, and the FLEX mission (selected as the Earth Explorer 8) are also under development.

Several phase 0 and A studies are going forward with top-priority scientific issues. For example: TRISHNA, a thermal infrared Earth observation project currently under discussion with India; WIZA, a concept of large swath altimeter part of an operational system of high resolution measurement of the oceans and continental waters' topography (in collaboration with ESA); and finally, the continuation of SKIM concept studies, pre-selected in November 2017 by ESA within the Earth Explorer 9 programme. This French proposal refers to a novel wide-swath scanning multibeam Doppler radar altimeter to measure ocean-surface currents.

Continuing with the progress made by the CNES balloon programme, 2017 has been particularly fertile, with 2 major missions achieved: EUSO-BALLONS, and PILOT's second flight which made it possible to measure the polarised submillimetric emission of interstellar dust from our Galaxy. The STRATEOLE-2 mission's validation campaign will begin in November 2018.

**SPACE SCIENCES AND EXPLORATION**

In the field of Space Sciences and exploration, planetology has entered a new golden age. After the glorious epic of ROSETTA and its spectacular epilogue which paved the way for the exploration of small bodies, France is participating in an asteroid sample-return mission with the lander MASCOT launched in 2014 on board Japan's HAYABUSA-2 spacecraft

which will reach Ryugu, its final destination between the 21 June and the 5 July 2018. The MMX mission to Phobos will share this ambition to return samples. Mars is still a top priority for the national community and the subject of several ongoing missions: MARS EXPRESS (ESA), NASA's CURIOSITY rover – the operations of the CHEMCAM and SAM instruments are planned from the Toulouse space centre – EXOMARS 2016, the TGO orbiter will begin its active operation phase while the 2 main French contributions of EXOMARS 2020, the MICROMEGA spectrometer and the WISDOM radar are in integration phase. As an extension of this passion for Mars, INSIGHT'S launch (NASA, May 2018), whose main instrument SEIS seismometer is French, arouses a high expectation; just like MARS2020 (NASA), CURIOSITY's successor which will carry the SUPERCAM camera. Over the past 2 years, the CASSINI operations ended but ESA's Large-class JUICE mission (JUper Icy moons) is under development with a strong involvement of France.

Milestones in Fundamental Physics in space include the cold-atom clock PHARAO which is awaiting launch to the International Space Station. The publication of MICROSCOPE's firsts results turned this incredible experiment into a global standard for the verification of the equivalence principle. After the success beyond expectation of LISA Pathfinder, ESA's selection of LISA as a L3 mission in June 2017 is a major decision for Europe and its member states. LISA's ambition is to observe gravitational waves from space.

In Solar and Plasma Physics, the exploitation of the SOHO and CLUSTER missions is ongoing while BEPICOLOMBO is almost ready to launch and SOLAR ORBITER is finalising its development. France contributes to the instruments of NASA's MMS mission which was launched in March 2015 and has begun delivering results. Finally, during summer 2018, the American PARKER SOLAR PROBE will begin its journey to the Sun. Its objective is to become the first spacecraft to enter the outer atmosphere of our star. CNES is supporting the participation of several French scientific laboratories.

In Astronomy-Astrophysics, after the success of PLANCK, the French and European cosmology community is expected to continue with EUCLID, under development by ESA. As for high energy, the Franco-Chinese mission SVOM is being developed and is to be launched in 2021. The French teams are also involved in ESA's future large X-ray

observatory ATHENA and CNES will be responsible for the development of the spectral and temporal high resolution spectrometer XIFU. After the publication of its second catalogue in April 2018, GAIA data are being exploited. It is the source of unprecedented information on almost 2 billion stars in our galaxy! At last, CNES supports the French scientific contribution to ESA's exoplanet missions, CHEOPS and PLATO as well as the ARIEL mission which just has got selected as a M4 mission within the Cosmic Vision programme.

In November 2016, the French astronaut Thomas Pesquet began a 6-month mission aboard the ISS, within the framework of the PROXIMA mission. Besides, an aircraft from the CNES subsidiary Novespace allows the French and European scientific community to conduct experiments in microgravity during parabolic flight campaigns. There are many scientific themes involved such as neuroscience, the physics of granular materials and various technology experiments.

In Life Sciences, the experiments in development are the BION-M2 mission in collaboration with Russia for monitoring the blood pressure of mice, and the start of the CARDIOSPACE mission's successor elaborated in partnership with China. CNES also supports the MEDES Space Clinic and its dry immersion studies. In 2017, the second campaign of the Bed Rest "Cocktail" study began at MEDES, on the adaptation mechanisms to 60 days of simulated microgravity and the effects of a nutritional countermeasure.

**SOCIAL SCIENCE**

On Social sciences, CNES continues its reflections for a better understanding of the impact of space activities on societal issues through a unified research programme in collaboration with French laboratories. The current dynamic is part of an opening to a wider variety of disciplines related to the social sciences and encouraging interdisciplinary approaches.

This fruitful period announces a fascinating 2019 Scientific Prospective Seminar. It is positioned at the crossroads of high-level ambitions in Universe Science, in Earth Science, in Condensed-matter Science, in Life Science, in exploration, in new technologies, and acceleration induced by next-generation processing (Big data, artificial intelligence, etc.) applied to ever denser data streams: the proximity of Science and of the digital world has never been so active or so promising!



Fig.2



Fig.3

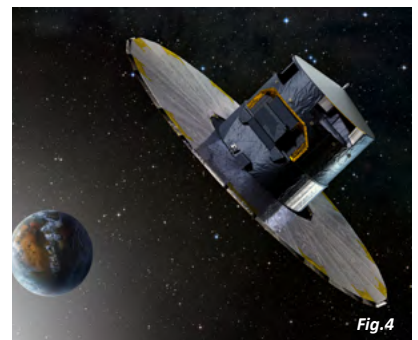


Fig.4

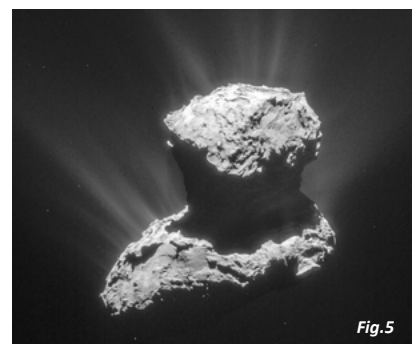


Fig.5

Fig. 1: Jean-Claude SOUYRIS © CNES/MALIGNE Frédéric, 2017  
 Fig. 2: « One Planet Summit » 11 December 2017. Space agencies worldwide propose the creation of a Space Climate Observatory © CNES/PEUS Christophe, 2017  
 Fig. 3: Artist's view of the MERLIN satellite © CNES/ill./DUCROS David, 2016  
 Fig. 4: Artist's view of the GAIA satellite © ESA/DUCROS David, 2013  
 Fig. 5: Comet Churyumov-Gerasimenko taken by the ROSETTA probe on 25 March 2015 at a distance of 86,6 km from the centre of comet. © ESA/ROSETTA/NAVCAM/, 2015